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EXCIMER GAS LASER OSCILLATOR

Inventors:	Hiroshi Uchida Toshiba Corporation Production Technology Research Laboratory, 8 Shinsugita-cho, Isoko-ku, Yokohama-shi, Kanagawa-ken

Tsutomu Kadono
Toshiba Corporation
Production Technology
Research Laboratory, 8
Shinsugita-cho, Isoko-ku,
Yokohama-shi,
Kanagawa-ken

Saburo Sato
Toshiba Corporation
Production Technology
Research Laboratory, 8
Shinsugita-cho, Isoko-ku,
Yokohama-shi,
Kanagawa-ken

Tatsumi Goto
Toshiba Corporation
Production Technology
Research Laboratory, 8
Shinsugita-cho, Isoko-ku,
Yokohama-shi,
Kanagawa-ken

Toshiba Corporation
Production Technology
Research Laboratory, 8
Shinsugita-cho, Isoko-ku,
Yokohama-shi, Kanagawa-ken

Applicant: Director of Industrial Technology
1-3-1 Kasumigaseki,
Chiyoda-ku, Tokyo

Examiner: Mitsuaki Hara

[There are no amendments to this patent.]

Claim

An excimer gas laser oscillator, characterized by the fact that in an excimer gas laser oscillator which oscillates the laser by sealing in an excimer gas laser medium within a gas laser pipe and generating a primary discharge between the primary discharge electrodes arranged in opposition within said gas laser pipe, a light-emitting element which radiates light with a wavelength in the photoabsorption band of the halogen donor composing said gas laser medium within said gas laser pipe, a light-receiving element which receives the light radiated with said light-emitting element and converts it into an electrical signal complying to the quantity of light received, and a gas feed control means which receives the electrical signal from said light-receiving element and controls the feed quantity of said halogen donor to said gas laser pipe so that the concentration of said halogen donor within said gas laser pipe becomes a prescribed value are provided.

Detailed explanation of the invention

Objective of the invention

Industrial application field

The present invention relates to an excimer gas laser oscillator.

Prior art

In gas laser oscillators, there are, for example, rare gas-halide excimer laser oscillators and CO_2 laser oscillators but the gas laser medium used in these laser oscillators is generally composed from several types of gas compositions and the composition thereof changes for each laser oscillation. For example, in that which uses a halogen donor as one composition for the gas laser medium as in an XeCl excimer laser oscillator with a mixed gas of Xe: 1% or less, HCl: 0.2% or less, and remainder He or Ne as the laser medium, the concentration of the halogen donor decreases for each laser oscillation. When the concentration decreases thus and becomes, for example, 0.1% or less as shown in Figure 4, the laser oscillation output decreases rapidly. Therefore, control is executed in a XeCl excimer laser oscillator, etc., such that the halogen donor concentration is always a prescribed value in order to minimize the influence on the laser output fluctuation caused by changes in the halogen donor concentration.

Therefore, the fixed-quantity halogen injection method and injection energy increase method were used as the methods for controlling said output fluctuation caused by changes in the halogen donor concentration. Figure 5 is a block diagram of an excimer laser oscillator in which the fixed-quantity halogen injection method has been applied and halogen gas bomb (3) is connected to excimer laser oscillator (1) via halogen injection valve (2). Also, operation shot number counter (4) which counts each laser oscillation is provided and this count value is transmitted to injection controller (5). Then, this injection controller (4) [sic; (5)] transmits an open operation signal to

halogen injection valve (2) when the operation shot number reaches a prescribed number and carries out the function of feeding a fixed-quantity of halogen donor to excimer laser oscillator (1). (6) is the high-voltage source which impresses a high-voltage between the primary discharge electrodes of excimer laser oscillator (1). Therefore, in a state in which halogen donor is not being fed, the halogen donor concentration gradually decreases for each laser oscillation along with the laser output decreasing gradually as shown in Figure 6. Then when the operation shot number reaches a prescribed value, halogen injection valve (2) is opened and halogen donor is fed to excimer laser oscillator (1). Therefore, along with the concentration of the halogen donor becoming high at this time, the laser output also becomes large.

Figure 7 is a block diagram of an excimer laser oscillator applied with the injection energy increase method, and injection controller (7) has a function of maintaining a high-voltage level impressed between primary discharge electrodes from high-voltage source (6) according to the count value increase in operation shot number counter (4). Namely, it is composed so that the voltage level, namely, injection energy impressed between the primary discharge electrodes, increases with increase in the operation shot number as shown in Figure 8 and the laser output becomes fixed.

However, in the aforementioned methods, there are the following problems. First of all, in the fixed-quantity halogen injection method, the halogen donor is fed intermittently, so the halogen donor concentration varies within a given range as shown in Figure 6; thus, the laser output fluctuates and becomes unstable. Furthermore, the halogen donor quantity injected each

time is determined by experience in this method so it is not possible to handle great changes in the operational condition such as when greatly changing the laser output, etc. In any case, the halogen donor concentration is not being detected directly in this method so the reliability with respect to halogen donor concentration control is low.

The injection energy increase method is what mandatorily makes the voltage level impressed between primary discharge electrodes high and is not what oscillates the laser beam at an optimal operational condition. Therefore, the impressed voltage becomes high as the frequency of the laser oscillation increases and in accordance, the life of the laser oscillator is short along with the stability and reliability being decreased in addition to the efficiency of the laser oscillation being decreased.

In actuality, control of the laser output and halogen donor concentration is being executed by combining the aforementioned methods, but said problems are created even when combined.

Problems to be solved by the invention

As noted above, a method for controlling the halogen donor concentration, namely, composition of the gas laser medium or the laser output to be fixed is being used but this cannot always maintain the halogen donor concentration at a prescribed value and decreases the reliability, stability, and life of the laser oscillator.

Therefore, the present invention aims to provide an excimer gas laser oscillator of high reliability and high stability,

capable of executing control so that the compositional ratio of the gas laser medium is always at a prescribed value.

Constitution of the invention

Means to solve the problems

The present invention is an excimer gas laser oscillator which attempts to achieve said objective by providing a light-emitting element which radiates light with a wavelength in the photoabsorption band of the halogen donor composing said gas laser medium within said gas laser pipe, a light-receiving element which receives the light radiated from said light-emitting element and converts it into an electrical signal complying to the quantity of light received, and a gas feed control means which receives the electrical signal from said light-receiving element and controls the feed quantity of said halogen donor to said gas laser pipe so that the concentration of said halogen donor within said gas laser pipe becomes a prescribed value in a gas laser oscillator which oscillates the laser by sealing in an excimer gas laser medium within a gas laser pipe and generating primary discharge between the primary discharge electrodes arranged in opposition within said gas laser pipe.

Function

Due to having provided said means, light with a wavelength in the photoabsorption band of the halogen donor composing the excimer gas laser medium is radiated from the light-emitting

element and this light is received with light-receiving element and converted into an electrical signal complying to the received quantity of light. Then, the gas feed control means receives the electrical signal from said light-receiving element and controls the feed quantity of said halogen donor to the gas laser pipe so that the concentration of the halogen donor within the gas laser pipe becomes a prescribed value.

Application example

Below, an application example of the present invention will be explained by referring to the figures.

Figure 1 is an overall block diagram of an excimer gas laser oscillator, and an excimer which includes a halogen donor as one part of the composition is sealed in the inside part of gas laser pipe (10) as the gas laser medium. Furthermore, primary discharge electrodes (11) and (12) arranged mutually opposed are provided on the inside part of said gas laser pipe (10) and total reflection mirror (13) and output mirror (14) which respectively compose a photoresonator are provided on each end part in the longitudinal direction of said primary discharge electrodes (11) and (12). High-voltage source (15) is connected between primary discharge electrodes (11) and (12) so that direct-current high-voltage +HV can be impressed. Also, halogen gas bomb (17) is connected to said gas laser pipe (10) via halogen injection valve (16).

Diode laser (20) as the light-emitting element is provided on one end in the longitudinal direction of said gas laser pipe (10) and the light emission is controlled by diode laser controller (21). The light emission wavelength of this diode

laser (20) is set to a wavelength in the photoabsorption zone of the halogen donor, and if HCl is used as the halogen donor as in a XeCl excimer laser, it is set to wave number 5664-8347 cm^{-1}. Also, Pbs semiconductor cell (22) as the light-receiving element is provided on the other end in the longitudinal direction of gas laser pipe (10), namely, at the opposing position of diode laser (20). This Pbs semiconductor cell (22) receives the diode laser beam which was radiated from diode laser (20) and advanced through the excimer atmosphere and outputs an electrical signal of the voltage level complying to the received quantity of light. Then, this electrical signal is transmitted to concentration controller (23). This concentration controller (23) has a function of receiving the electrical signal from Pbs semiconductor cell (22), obtaining the present halogen donor concentration from the voltage level thereof, comparing this concentration with the reference concentration, and successively transmitting opening operation signals to halogen injection valve (16) so that the halogen donor concentration becomes the reference concentration.

Next, the function of a device composed as noted above will be explained.

When a high-voltage is impressed from high-voltage source (15) between primary discharge electrodes (11) and (12) and primary discharge is generated between primary discharge electrodes (11) and (12), optical resonance is generated between total reflection mirror (13) and output mirror (14), and the laser beam is output from output mirror (14). When laser beam is oscillated thus, the concentration of the halogen donor decreases along with this laser output becoming small as shown in Figure 4.

However, in this device, diode laser (20) is always emitting light of the same wavelength as the photoabsorption band of the halogen according to diode laser controller (21). Then, this diode laser beam reaches Pbs semiconductor cell (22) by transmitting through the gas laser medium. Therefore, a portion of the diode laser beam is absorbed while being transmitted through the gas laser medium according to the concentration of the halogen donor. Then, Pbs semiconductor cell (22) receives the diode laser beam and outputs an electrical signal of a voltage level complying to the received quantity of light. This electrical signal is transmitted to concentration controller (23), and concentration controller (23) obtains the halogen donor concentration from the voltage level of the electrical signal, compares it with the reference concentration, creates an open operation signal so that the halogen donor concentration becomes the reference concentration, and transmits to halogen injection valve (16). As a result, the concentration of the halogen donor composing the gas laser medium is always controlled to be the prescribed value. Figure 2 is a figure showing the laser output and the halogen donor concentration when the aforementioned halogen donor concentration control is executed. The halogen donor concentration is always fixed, and the laser output at this time is more or less fixed even if the operation shot number becomes 10^5 or more. Also, when the efficiency of the laser oscillation is observed, it is apparent that the present device has a high efficiency compared to the fixed-quantity halogen injection method and the injection energy increase method as shown in Figure 3.

As noted above, in the aforementioned application example, it was composed to radiate light of a wavelength in the

photoabsorption band of the halogen donor composing the gas laser medium from diode laser (20), receive this light with Pbs semiconductor cell (22), and control the feed quantity of halogen donor to gas laser pipe (10) with concentration controller (23) according to the received quantity of light so the halogen donor concentration can always be monitored, and if the concentration decreases, it is possible to feed halogen donor at the time of this decrease and maintain the halogen donor at a prescribed value. Therefore, the laser output can always be kept in a stable state regardless of the laser oscillation frequency. Also, the measurement of halogen concentration uses the light radiated from diode laser (20) so there is no influence from gas contamination, etc., within gas laser pipe (10) on the measurement, and on the contrary can simplify prevention of problems such as corrosion of the halogen-concentration measuring device (sensor) from the gas laser medium, etc.

Effect of the invention

As noted above, according to the present invention, an excimer gas laser oscillator of high reliability and high stability capable of controlling the composition ratio of the excimer gas laser medium to always at the prescribed value can be provided.

Brief description of the figures

Figures 1-3 are figures for explaining an application example of the excimer gas laser oscillator related to the present invention; Figure 1 is an overall block diagram; Figure 2

is a graph showing the laser output and halogen donor concentration with respect to the operation shot number; Figure 3 is a graph showing the efficiency with respect to the operation shot number; Figure 4 is a graph showing the laser output with respect to the halogen donor concentration; and Figures 5-8 are figures for explaining the conventional technology.

(10)...gas laser pipe, (11), (12)...primary discharge electrodes, (13)...total reflection mirror, (14)...output mirror, (15)...high-voltage source, (16)...halogen injection valve, (17)...halogen gas bomb, (20)...diode laser, (21)...diode laser controller, (22)...Pbs semiconductor cell, (23)...concentration controller.

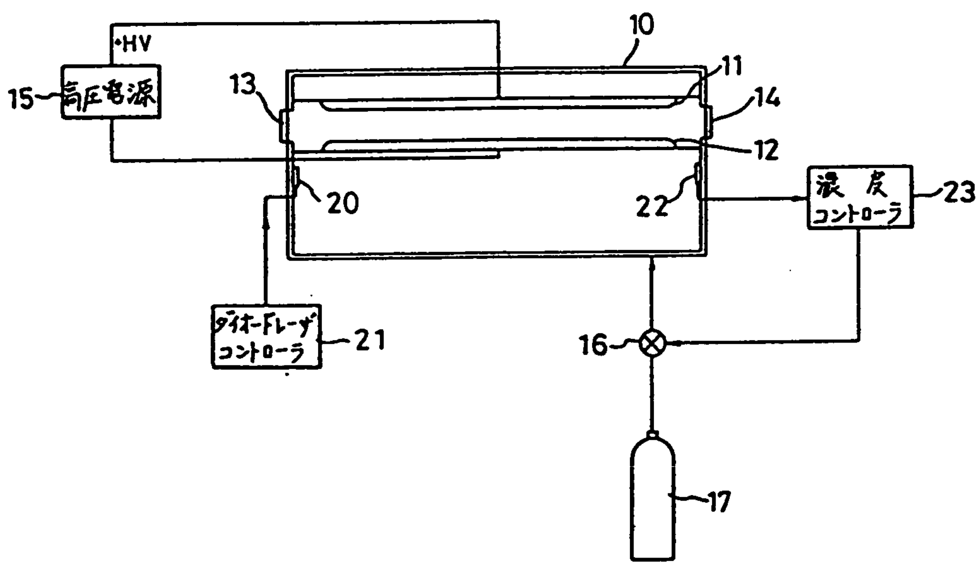

Figure 1

Key: 15 High-voltage source
     21 Diode laser controller
     23 Concentration controller

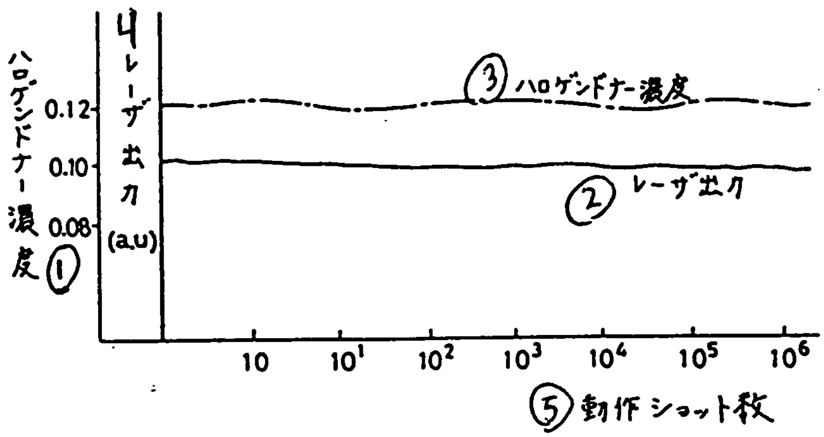

Figure 2

Key: 1 Halogen donor concentration
     2 Laser output
     3 Halogen donor concentration
     4 Laser output (au)
     5 Operation shot number

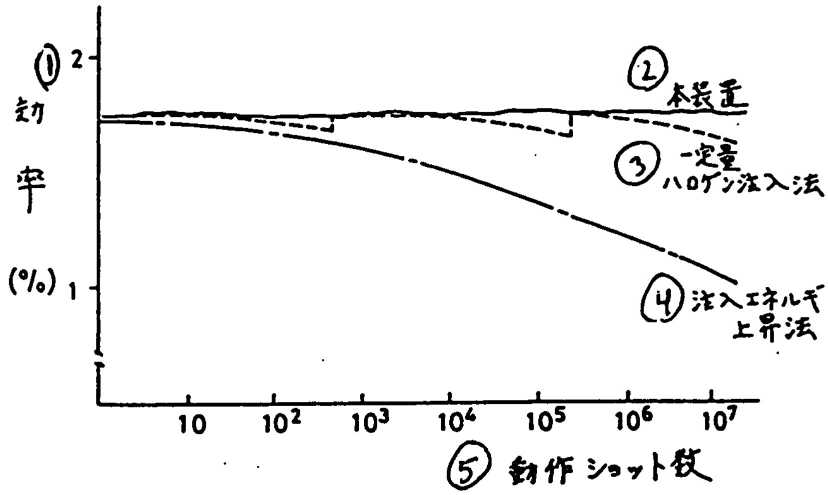

Figure 3

Key: 1 Efficiency (%)
2 Present device
3 Fixed-quantity halogen injection method
4 Injection energy increase method
5 Operation shot number

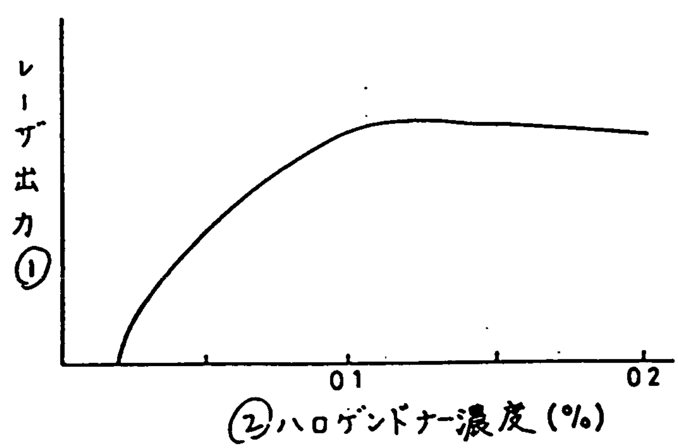

Figure 4

Key: 1 Laser output
2 Halogen donor concentration (%)

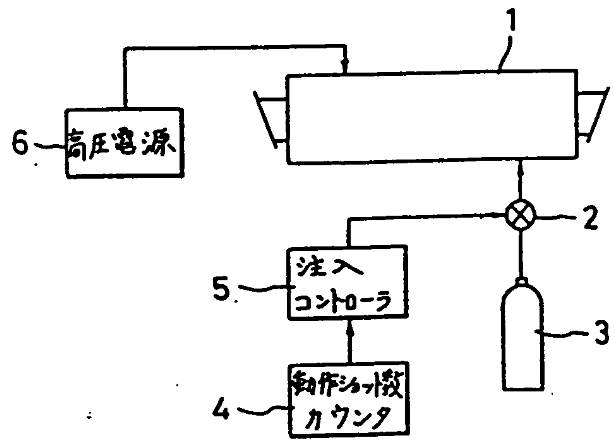

Figure 5

Key: 4 Operation shot number counter
5 Injection controller
6 High-voltage source

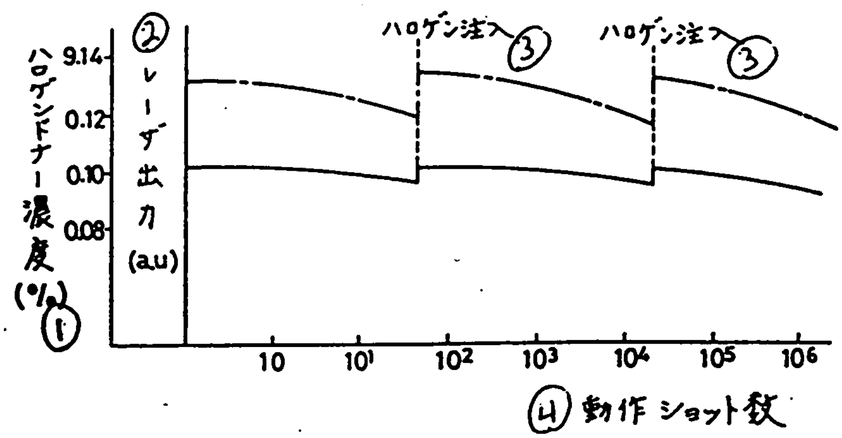

Figure 6

Key: 1 Halogen donor concentration (%)
2 Laser output (au)
3 Halogen injection
4 Operation shot number

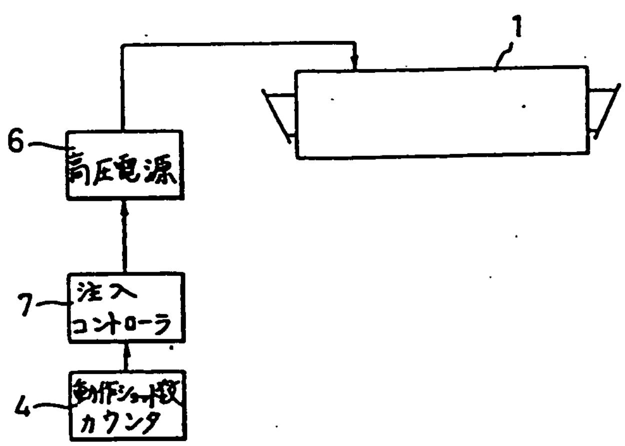

Figure 7

Key: 4 Operation shot number counter
6 High-voltage source
7 Injection controller

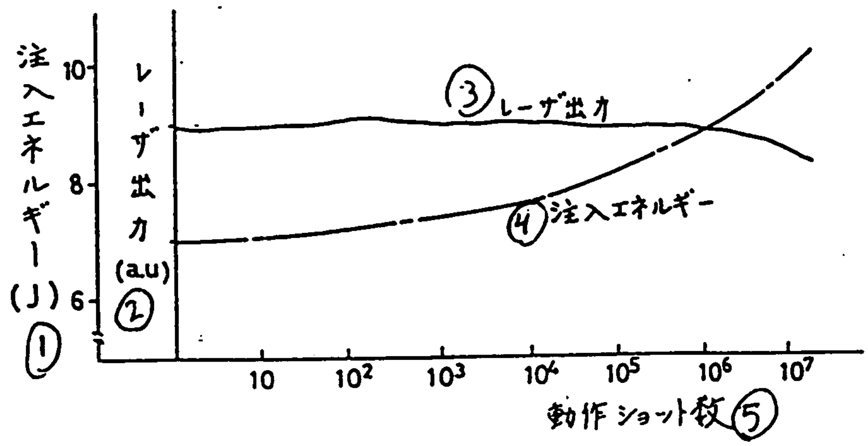

Figure 8

Key: 1 Injection energy (J)
2 Laser output (au)
3 Laser output
4 Injection energy
5 Operation shot number

(8)

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請求項の数 1　（全6頁）

⑤発明の名称　エキシマガスレーザ発振装置

②

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㉒出　願　昭63(1988)7月27日　　㊸平2(1990)2月6日

⑫発 明 者　内　田　　裕　神奈川県横浜市磯子区新杉田町8番地　株式会社東芝生産技術研究所内

⑫発 明 者　角　野　　努　神奈川県横浜市磯子区新杉田町8番地　株式会社東芝生産技術研究所内

⑫発 明 者　佐　藤　三　郎　神奈川県横浜市磯子区新杉田町8番地　株式会社東芝生産技術研究所内

⑫発 明 者　後　藤　達　美　神奈川県横浜市磯子区新杉田町8番地　株式会社東芝生産技術研究所内

⑦出 願 人　工業技術院長　東京都千代田区霞が関1丁目3番1号

審 査 官　原　　光　明

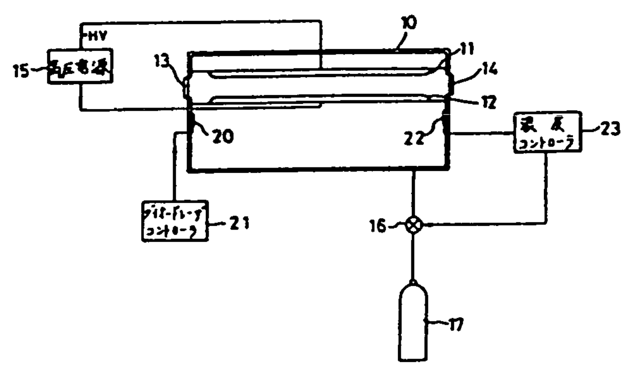
目的

本発明は、ガスレーザ媒質の組成比が常に所定値となるように制御できる高安定性で高信頼性のエキシマガスレーザ発振装置を提供することを目的とする。

⑤特許請求の範囲

1　ガスレーザ管内にエキシマガスレーザ媒質を封入し前記ガスレーザ管内に対向配置した各主放電電極間に主放電を発生させてレーザ発振するエキシマガスレーザ発振装置において、前記ガスレーザ媒質を組成するハロゲンドナーの光吸収帯域における波長の光を前記ガスレーザ管内に照射する発光素子と、この発光素子で照射された光を受光して受光量に応じた電気信号に変換する受光素子と、この受光素子からの電気信号を受けて前記ガスレーザ管内における前記ハロゲンドナーの濃度が所定値となるようにこのハロゲンドナーの前記ガスレーザ管への供給量を制御するガス供給制御手段とを具備したことを特徴とするエキシマガスレーザ発振装置。

第1図

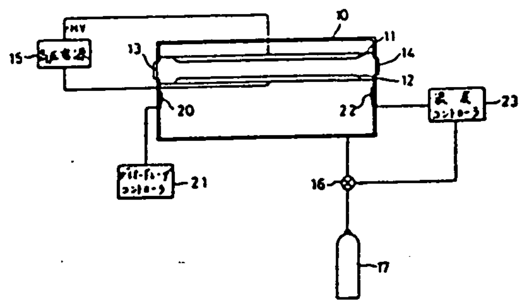


図面の簡単な説明

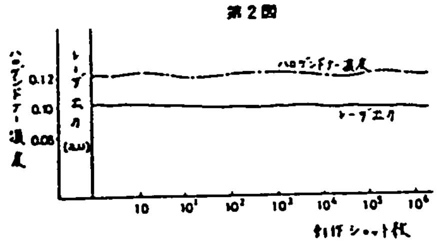
第1図乃至第3図は本発明に係わるエキシマガスレーザ発振装置の一実施例を説明するための図であつて、第1図は全体構成図、第2図は動作ショット数に対するハロゲンドナー濃度及びレーザ出力を示す図、第3図は動作ショット数に対する効率を示す図、第4図はハロゲンドナー濃度に対するレーザ出力を示す図、第5図乃至第8図は従来技術を説明するための図である。

10……ガスレーザ管、11，12……主放電電極、13……全反射ミラー、14……出力ミラー、15……高圧電源、16……ハロゲン注入弁、17……ハロゲンガスボンベ、20……ダイオードレーザ、21……ダイオードレーザコントローラ、22……Pbs半導体セル、23……濃度コントローラ。

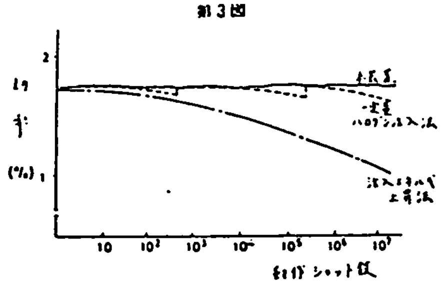
第1図



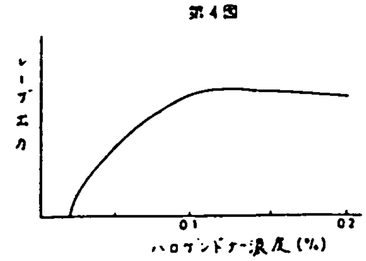
第2図



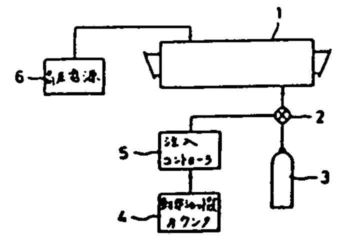
第3図



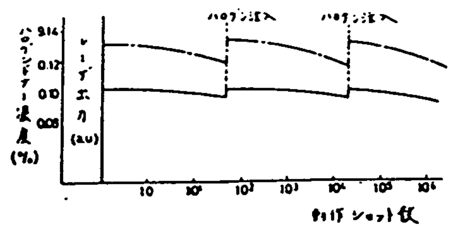
第4図



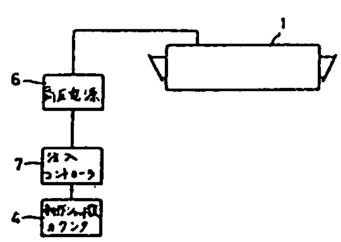
第5図



第6図



第7図



第8図